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(54) **IMAGE FORMING APPARATUS**

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(51) **Int. Cl.**
G03G 21/20 (2006.01)

(52) **U.S. Cl.** **399/92**; 399/111

(58) **Field of Classification Search** 399/91, 399/92, 107, 110, 111, 113, 116
See application file for complete search history.

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(57) **ABSTRACT**

An image forming apparatus includes: a photosensitive element; a charger for electrically charging the photosensitive element; an exposure device for scanning laser light across the photosensitive element that has been electrically charged by the charger; an exposure window positioned away from the exposure device for a predetermined distance and through which the laser light passes; and an exhaust fan for drawing air between the exposure device and the exposure window toward the charger and discharging the air from the image forming apparatus. The exposure window is defined by a plurality of walls, in which a first wall that is the farthest wall from the charger and a second wall that is the nearest wall from the charger satisfy a formula: A<B, where A is a distance between the first wall and the exposure device, and B is a distance between the second wall and the exposure device.

9 Claims, 2 Drawing Sheets

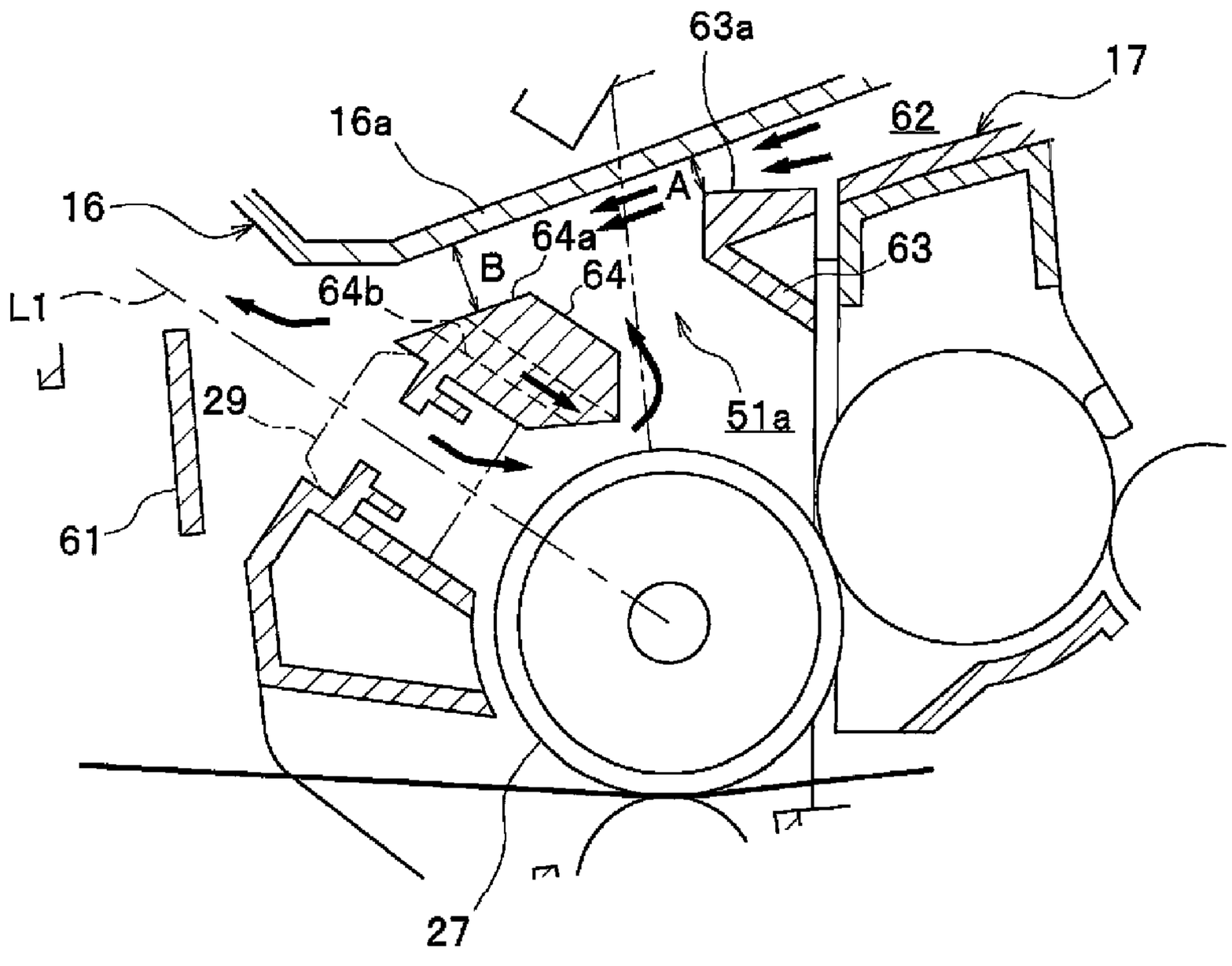
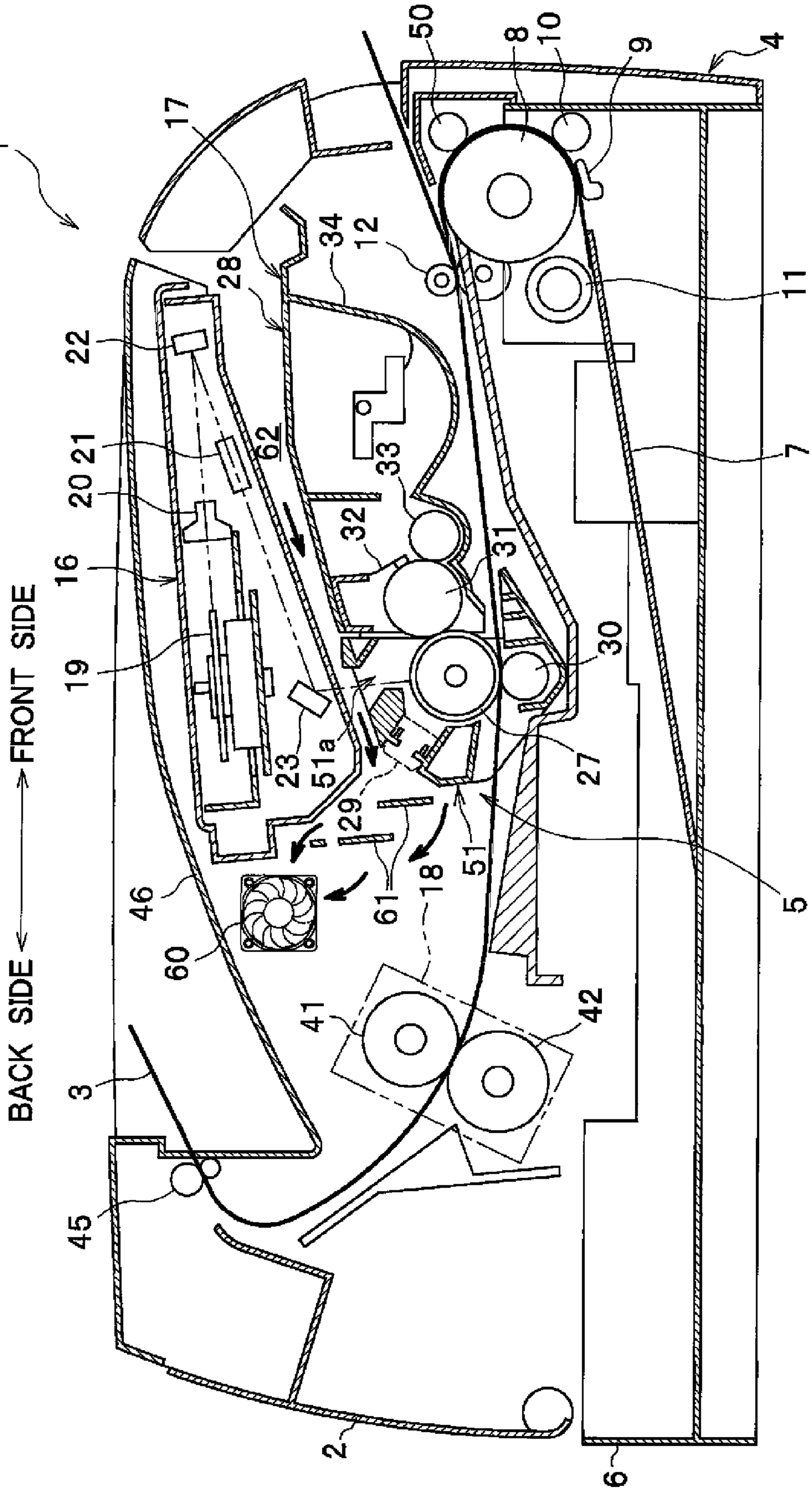


FIG. 1


1
50
8
10
9
4
17
34
12
28
11
22
21
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62
33
7
16
32
31
19
30
23
51a
27
129
51
5
18
61
46
60
2
41
42
3
45
6
FRONT SIDE
BACK SIDE

FIG. 2

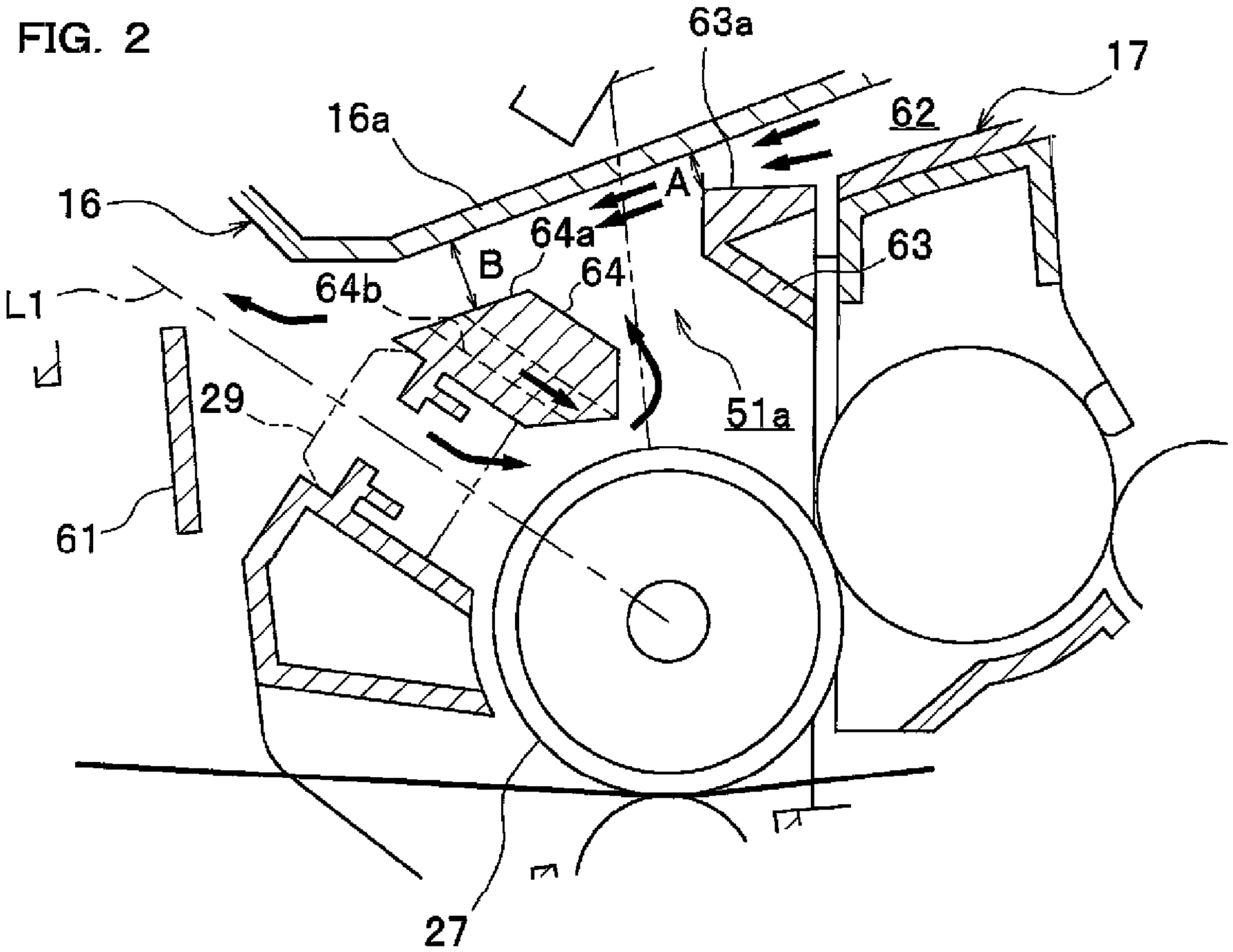
63a
17
16a
62
16
A
64a
63
B
64
64b
L1
29
51a
61
27

FIG. 3

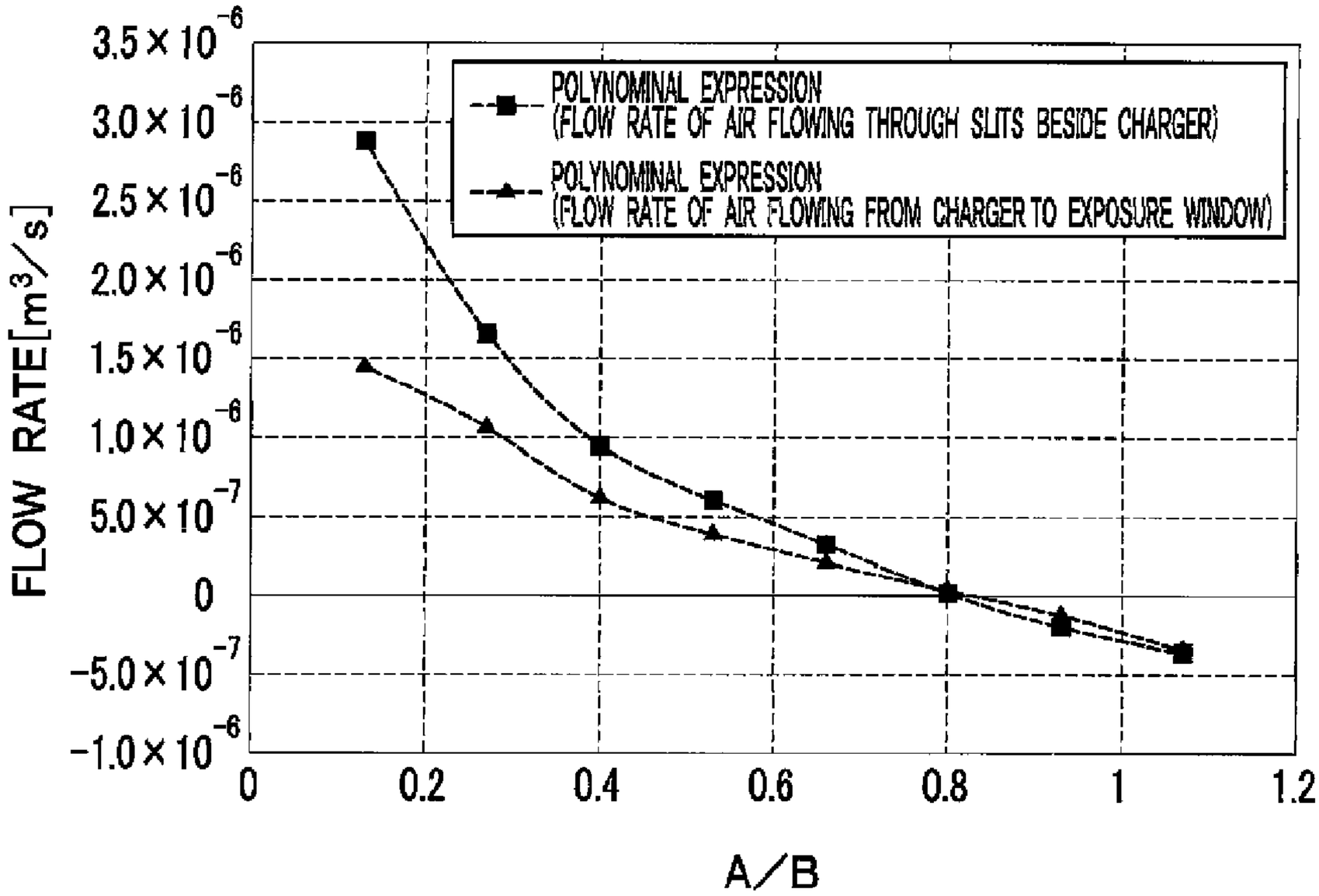
POLYNOMINAL EXPRESSION
(FLOW RATE OF AIR FLOWING THROUGH SLITS BESIDE CHARGER)
POLYNOMINAL EXPRESSION
(FLOW RATE OF AIR FLOWING FROM CHARGER TO EXPOSURE WINDOW)
FLOW RATE[m3/s]
3.5×10-6
3.0×10-6
2.5×10-6
2.0×10-6
1.5×10-6
1.0×10-6
5.0×10-7
0
-5.0×10-7
-1.0×10-6
0
0.2
0.4
0.6
0.8
1
1.2
A/B

IMAGE FORMING APPARATUS

CROSS REFERENCE TO RELATED APPLICATIONS

This application claims the foreign priority benefit under Title 35, United States Code, §119(a)-(d) of Japanese Patent Application No. 2006-293089 filed on Oct. 27, 2006 in the Japan Patent Office, the disclosure of which is herein incorporated by reference in its entirety.

BACKGROUND OF THE INVENTION

The present invention relates to an image forming apparatus equipped with a charger for electrically charging a photosensitive element and an exhaust fan for ventilating the image forming apparatus.

Generally, a known image forming apparatus electrically charges a photosensitive drum and emits laser light on this electrically charged photosensitive drum so that the electric potential of the exposed area (i.e., area on which the laser light is emitted) lowers to form an electrostatic latent image on the photosensitive drum. The image forming apparatus then supplies developer on this latent image to form a developer image, which is transferred on a paper so that a predetermined image is formed on the paper.

As one example of such an image forming apparatus, Japanese Laid-open Patent Application No. 2005-292356, which corresponds to US 2005/0220479A1, discloses an image forming apparatus equipped with a scanner unit for scanning laser light and a process unit positioned below the scanner unit with a predetermined gap interposed therebetween. This image forming apparatus mainly includes in the process unit a photosensitive drum for carrying developer images, a charger for electrically charging the photosensitive drum, and an exposure window through which laser light from the scanner unit is emitted on to the photosensitive drum. The charger and the exposure window are arranged adjacent to each other.

This kind of image forming apparatus is usually provided with an exhaust fan for mainly discharging heat from the inside of the apparatus. Air between the scanner unit and the process unit is drawn by the exhaust fan from the exposure window toward the charger so as to perform a heat discharging operation, etc.

However, when the exhaust fan draws air between the scanner unit and the process unit, there may be a possibility that air flows into the process unit through the exposure window, etc. and then flows out from the process unit through the charger. If this happens, contrary to ion flow generated during the electric charge by the charger (i.e., airflow generated by the movement of ions upon electric charge) and directed from the charger to the photosensitive drum, the operation of the exhaust fan generates airflow which flows in the counter direction of the ion flow. As a result, efficiency of electric charge may be decreased by this counter flow.

In view of the foregoing drawback of the conventional image forming apparatus, the present invention seeks to provide an image forming apparatus which can prevent a decrease in efficiency of electric charge.

SUMMARY OF THE INVENTION

According to the present invention, there is provided an image forming apparatus comprising: a photosensitive element; a charger for electrically charging the photosensitive element; an exposure device for scanning laser light across the photosensitive element that has been electrically charged by the charger; an exposure window positioned away from the exposure device for a predetermined distance and through which the laser light passes; and an exhaust fan for drawing air between the exposure device and the exposure window toward the charger and discharging the air from the image forming apparatus. The exposure window is defined by a plurality of walls, in which a first wall that is the farthest wall from the charger and a second wall that is the nearest wall from the charger satisfy a formula: A<B, where A is a distance between the first wall and the exposure device, and B is a distance between the second wall and the exposure device.

With this configuration of the image forming apparatus, the exposure window is defined by a plurality of walls including a first wall that is the farthest wall from the charger and a second wall that is the nearest wall from the charger, and the distance A between the first wall and the exposure device and the distance B between the second wall and the exposure device satisfy the formula: A<B. Therefore, the flow velocity of the airflow flowing through a space between the first wall and the exposure device is higher than the flow velocity of the airflow flowing through a space between the second wall and the exposure device. This makes it possible to restrict the amount of air flowing into the process unit through the exposure window, so that an occurrence of the counter airflow flowing in the opposite direction of the ion flow that is generated upon electric charge by the charger can be restricted. As a result, it is possible to restrict a decrease in the efficiency of electric charge.

BRIEF DESCRIPTION OF THE DRAWINGS

Other objects and aspects of the present invention will become more apparent by describing in detail illustrative, non-limiting embodiments thereof with reference to the accompanying drawings, in which:

FIG. **1** is a side sectional view illustrating a laser printer as one example of an image forming apparatus according to the present invention;

FIG. **2** is an enlarged sectional view showing the structure around a longitudinal airway defined in the laser printer; and

FIG. **3** is a graph explaining relations between ratio A/B of distances A and B and flow rate at predetermined points.

DETAILED DESCRIPTION OF THE INVENTION

With reference to FIG. **1**, brief description will be given on the overall structure of a laser printer as one example of an image forming apparatus according to the present invention.

Overall Structure of Laser Printer

As seen in FIG. **1**, a laser printer **1** includes a main body casing **2**, and provided in the main body casing **2** are a feeder unit **4** for feeding papers **3**, an image forming unit **5** for forming an image on a paper **3** to be fed from the feeder unit **4**, etc. In the following description, unless otherwise stated, the right side of FIG. **1** is referred to as a "front or near side" and the left side of FIG. **1** is referred to as a "back or far side", based on the directions where the user stands in front of the laser printer **1** and looks at the same upon using the laser printer **1**.

Structure of Feeder Unit

The feeder unit **4** includes a paper feed tray **6** slidable into and detachable from a bottom space provided in the main body casing **2**, and a paper lifting plate **7** provided in the paper feed tray **6**. The feeder unit **4** further includes a pick-up roller **11** provided above the paper feed tray **6** at one end side thereof, a feed roller **8** positioned downstream of the pick-up

roller **11** as seen in the conveying direction of papers **3**, a paper feed pad **9**, a pinch roller **10**, and a cleaning roller **50** for removing paper dust. Further, a paper stop roller **12** is provided in the feeder unit **4** at a position downstream of the cleaning roller **50**.

According to this feeder unit **4**, the paper lifting plate **7** collects papers **3** in the paper feed tray **6** toward the pick-up roller **11**. The pick-up roller **11** then picks up and feeds out a paper **3** between the feed roller **8** and the paper feed pad **9** at which the paper **3** is fed out on a one-by-one basis. The paper **3** then passes the rollers **10**, **50**, **12** and is conveyed to the image forming unit **5**.

Structure of Image Forming Unit

The image forming unit **5** includes a scanner unit **16** as one example of an exposure device, a process cartridge **17**, a fixing unit **18**, etc.

Structure of Scanner Unit

The scanner unit **16** is provided at an upper part of the main body casing **2**. The scanner unit **16** includes a laser light emitting device (not shown), a rotatable polygon mirror **19**, a plurality of lenses **20**, **21**, and reflecting mirrors **22**, **23**. A laser beam is emitted from a laser light emitting device based on image data. As shown by the chain line of FIG. **1**, the laser beam emitted from the laser light emitting device passes in order through or is reflected at the polygon mirror **19**, the lens **20**, the reflecting mirror **22**, the lens **21**, and the reflecting mirror **23**, and thereafter it is irradiated onto the photosensitive drum **27** of the process cartridge **17** by high speed scanning.

Structure of Process Cartridge

The process cartridge **17** is arranged below the scanner unit **16** with a predetermined gap interposed therebetween. The process cartridge **17** is attached to and detachable from the main body casing **2**. The process cartridge **17** mainly consists of a developer cartridge **28** and a drum unit **51**.

The developer cartridge **28** is attached to and detachable from the drum unit **51**, and includes a development roller **31**, a doctor blade **32**, a supply roller **33**, and a toner hopper **34**. Toner stored in the toner hopper **34** is supplied to the development roller **31** by the supply roller **33**, during which the toner charges positively due to frictional contact between the supply roller **33** and the development roller **31**. When the development roller **31** rotates, the toner deposited on the development roller **31** passes through a space between the doctor blade **32** and the development roller **31**, so that the toner is carried on the development roller **31** as a thin layered toner having a constant thickness.

The drum unit **51** mainly includes a photosensitive drum **27** as one example of the photosensitive element, a Scorotron charger **29** as one example of the charger, and a transfer roller **30**.

The photosensitive drum **27** is rotatably supported in the housing of the drum unit **51**. The photosensitive drum **27** has a drum main body to be earthed, and the surface of the photosensitive drum **27** is made of a photosensitive layer to be charged positively. An exposure window **51***a* is arranged above the photosensitive drum **27**. The exposure window **51***a* is provided as an opening formed in the housing of the drum unit **51**.

The Scorotron charger **29** is positioned away from the photosensitive drum **27** with a predetermined gap interposed therebetween. To be more specific, the Scorotron charger **29** is positioned diagonally upward from the photosensitive drum **27** (i.e., backward and upward from the photosensitive drum **27**) facing to the photosensitive drum **27**. The Scorotron charger **29** (hereinafter referred to as the "charger **29**") is a Scorotron-type charger having a charging wire made of tungsten or the like for producing corona discharge and configured to electrically charge the surface of the photosensitive drum **27** uniformly in the plus polarity. Ion flow is generated in the charger **29** due to corona discharge. The ion flow flows in the direction from the charger **29** to the photosensitive drum **27**.

The transfer roller **30** is rotatably supported in the housing of the drum unit **51** at a position under the photosensitive drum **27** and opposed to and in contact with the photosensitive drum **27**. The transfer roller **30** has a metallic roller shaft covered with a conductive rubber material. During the transfer process, a transfer bias is applied to the transfer roller **30** under constant current control.

In operation, the surface of the photosensitive drum **27** is uniformly charged to the plus polarity by the charger **29**, and thereafter exposed to the laser beam from the scanner unit **16** by high speed scanning. This exposure process lowers the potential of the exposed surface on the photosensitive drum **27**, thereby forming an electrostatic latent image based on the image data. The term "electrostatic latent image" indicates an invisible image produced on the uniformly positively charged surface of the photosensitive drum **27** with the exposed area made lower in potential by exposure to the laser beam. Next, as the development roller **31** rotates, toner deposited on the development roller **31** comes into contact with the opposed photosensitive drum **27** so that the toner is supplied to the electrostatic latent image formed on the photosensitive drum **27**. The toner is selectively retained on the photosensitive drum **27** solely in the area corresponding to the electrostatic latent image, so as to visualize the latent image. This reversal development forms a toner image on the photosensitive drum **27**.

Thereafter, the photosensitive drum **27** and the transfer roller **30** rotate so that the paper **3** is held and fed forward between the rollers **27**, **30**, during which the toner image formed on the surface of the photosensitive drum **27** is transferred to the paper **3**.

Structure of Fixing Unit

The fixing unit **18** is positioned downstream of the process cartridge **17**, and includes a heating roller **41**, and a pressure roller **42** opposed to and pressing the heating roller **41**. In the fixing unit **18** as constructed above, the toner image transferred onto the paper **3** is fixed by heating and fusing the toner while the paper **3** passes between the heating roller **41** and the pressure roller **42**. The paper **3** that has been fixed by heating and fusing at the fixing unit **18** is conveyed to a paper output roller **45** positioned downstream of the fixing unit **18**, and thereafter discharged from the paper output roller **45** onto a paper output tray **46**.

In order to exhaust heat in the laser printer **1**, an exhaust fan **60** is provided between the fixing unit **18** and the scanner unit **16**. Provided below the exhaust fan **60** and between the fixing unit **18** and the process cartridge **17** is a duct **61** for rectifying and regulating a flow of air.

By this arrangement of the exhaust fan **60** and the duct **61**, when the exhaust fan **60** is operated, the exhaust fan **60** sucks air between the drum unit **51** and the fixing unit **18** directly or through the duct **61** and discharges the air to the outside. The exhaust fan **60** also sucks air from the front upper side of the laser printer **1** through a passage formed between the scanner unit **16** and the process cartridge **17**, that is an airway **62** extending in the longitudinal direction of the laser printer **1**, and then discharges the air to the outside. Structure around the airway **62** will be described below in detail.

Structure Around Airway

As seen in FIG. **2**, the scanner unit **16** by which the upper wall of the airway **62** is defined is arranged in a position not across (i.e., offset from) the extension L**1** extending from the line connecting the center of the photosensitive drum **27** and the center of the charger **29**. Further, as shown in FIG. **1**, the photosensitive drum **27**, the charger **29**, and the exhaust fan **60** are arranged in line. Furthermore, the duct **61** is provided at a position opposed to the outlet of the airway **62**. By this arrangement of the parts, the flow direction of the airflow coming from the exposure window **51***a* and flowing toward the charger **29** is bent around the charger **29** in a direction away from the photosensitive drum **27**.

Back side of the airway **62** comprises a scanner plate **16***a* by which the lower wall of the scanner unit **16** is defined, and a first wall **63** and a second wall **64** which form the exposure window **51***a*. The first wall **63** is a wall that is positioned farthest from the charger **29**, and the second wall **64** is a wall that is positioned nearest from the charger **29**. The charger **29** is adjacent to the second wall **64** and positioned behind the second wall **64**, i.e., downstream of the second wall **64** as seen in the flow direction of air. The second wall **64** has a plurality of openings **64***b* with a predetermined pitch in the right and left direction (i.e., direction orthogonal to the drawing plane). Further, the first wall **63** and the second wall **64** are arranged such that the distance between the first and second walls **63**, **64** is in the range from 5 to 30 mm.

The first wall **63** is provided with a projection **63***a* which protrudes upward relative to the upper surface **64***a* of the second wall **64**, so that the airway **62** is restricted at the projection **63***a*. To be more specific, the distance A between the first wall **63** and the scanner plate **16***a* in the direction orthogonal to the scanner plate **16***a* and the distance B between the second wall **64** and the scanner plate **16***a* satisfy the following formulae:

$$A<B \tag{1}$$

$$A/B<0.8 \tag{2}$$

Next, the influence of the projection **63***a* provided in the airway **62** will be described.

As shown in FIG. **1**, when the exhaust fan **60** is operated, the exhaust fan **60** sucks air from the front upper side of the laser printer **1** through the longitudinal airway **62** so that air flows in the airway **62** toward the back side of the laser printer **1**. As shown in FIG. **2**, when the air passes through the space defined by the projection **63***a* of the first wall **63** and the scanner plate **16***a*, the flow velocity of the air is increased because the sectional area of the airway **62** is restricted at the projection **63***a*. As a result, most of the air flows in the airway **62** without flowing into the process cartridge **17** through the exposure window **51***a*, and then flows upward away from the charger **29**.

In other words, the airflow passing along the projection **63***a* of the first wall **63** has a higher flow velocity than the airflow passing along the second wall **64**, so that pressure is reduced at the downstream side of the first wall **63** (i.e., upper space of the exposure window **51***a*) than at the downstream side of the second wall **64** (i.e., upper space of the charger **29**). Therefore, air at the upper side of the charger **29** is drawn and flows into the charger **29** and the process cartridge **17** and flows out from the process cartridge **17** through the exposure window **51***a*. This makes it possible to restrict an occurrence of the counter airflow flowing from the inside to the outside of the process cartridge **17** through the charger **29**. Thereafter, the flow of air is bent around the charger **29** in a diagonally upward direction toward the exhaust fan **60** and away from the photosensitive drum **27**, and then flows out to the outside from the exhaust fan **60**.

According to the laser printer **1** as constructed above, the following advantages can be obtained.

(1) The flow velocity increases when airflow passes through the restriction defined by the projection **63***a*, so that the amount of air flowing into the process cartridge **17** through the exposure window **51***a* can be decreased. It is possible to restrict an occurrence of the counter airflow flowing in the opposite direction of the ion flow that is generated upon electric charge by the charger **29**, thereby restricting a decrease in the efficiency of electric charge.

(2) The distance A and the distance B have a relation to satisfy the formula (2) defined by A/B<0.8, so that airflow flowing through the space between the second wall **64** and the photosensitive drum **27** flows in the direction away from the charger **29** (i.e., direction toward the front side of the laser printer **1**). It is possible to reliably restrict a decrease in the efficiency of electric charge. The flow direction of the airflow between the second wall **64** and the photosensitive drum **27** was proved by experiments carried out by the inventor. See Example to be described later.

(3) Since the distance from the first wall **63** to the second wall **64** is in the range from 5 to 30 mm, the opening area of the exposure window **51***a* becomes relatively small. This makes it possible to restrict air from flowing into the process cartridge **17** through the exposure window **51***a* while reliably guiding laser light from the scanner unit **16** to the photosensitive drum **27**.

The present invention is not limited to the above specific embodiment, and various changes and modifications may be made without departing from the scope of the attached claims.

According to the above preferred embodiment, the projection **63***a* is provided on the first wall **63**. However, a projection may be provided on the bottom wall of the scanner plate **16***a* opposed to the first wall **63**, or a projection may be provided both on the scanner plate **16***a* and the first wall **63**.

Although the present invention has been described as being applied to a laser printer, the present invention is applicable to other image forming apparatus such as a copying machine and a multifunction device.

Example

One example for the above preferred embodiment will be described below. More specifically, experimental results (simulation results) are shown for relations between ratio A/B of the distance A to the distance B and flow rate of air at predetermined points.

In the experiments (simulations) according to this example, the exhaust fan **60**, the charger **29**, the exposure window **51***a*, the first wall **63**, the second wall **64**, etc. are arranged as described above in the preferred embodiment. To be more specific, arrangements of the parts are the same as those of HL-2040 model laser printer manufactured by Brother Industries, Ltd. except for the height of the projection **63***a* provided on the first wall **63**. The flow rate of air discharged by the exhaust fan **60** is 4.25×10^{-6} m^3/s. While maintaining these conditions, the height of the projection **63***a* on the first wall **63** is changed in accordance with the TABLE 1 below, and measurements are made for the flow rate of air flowing through the openings **64***b* formed in the second wall **64** and the flow rate of air flowing through a space between the second wall **64** and the photosensitive drum **27**. Accordingly, the experimental results as shown in TABLE 1 and FIG. **3**

were obtained. Plus-minus signs (plus sign is omitted) found in TABLE 1 at columns indicating flow rate are determined such that plus sign is used for the flow rate of air flowing through the openings **64***b* of the second wall **64** in the direction from the outside to the inside of the process cartridge **17** and that plus sign is used for the flow rate of air flowing through the space between the second wall **64** and the photosensitive drum **27** in the direction from the charger **29** to the exposure window **51***a*.

TABLE 1

A/B	Flow rate of air flowing through openings of second wall (m^3/s)	Flow rate of air flowing through a space between second wall and photosensitive drum (m^3/s)
1.07	-3.54×10^{-7}	-3.43×10^{-7}
0.93	-1.98×10^{-7}	-1.25×10^{-7}
0.80	1.57×10^{-8}	3.26×10^{-8}
0.66	3.28×10^{-7}	2.08×10^{-7}
0.53	6.05×10^{-7}	3.91×10^{-7}
0.40	9.49×10^{-7}	6.18×10^{-7}
0.27	1.66×10^{-6}	1.06×10^{-6}
0.13	2.88×10^{-6}	1.44×10^{-6}

According to this example, when the ratio of the distance A to the distance B is set to satisfy A/B<0.8, it is proved that air flowing through the space between the second wall **64** and the photosensitive drum **27** is directed to the direction from the charger **29** to the exposure window **51***a*. Also, when the condition A/B<0.8 is satisfied, it is proved that air flowing through the openings **64***b* of the second wall **64** is directed to the direction from the outside to the inside of the process cartridge **17** and that a counter flow of air does not occur, which flows into the process cartridge **17** through the exposure window **51***a* and flows out from the openings **64***b* of the second wall **64**. As described above, when the condition A/B<0.8 is satisfied, it is proved that ion flow generated upon electric charge by the charger **29** is hardly interrupted by other airflow and a smooth and favorable flow of the ion flow can be obtained.

On the contrary, when A/B is 0.93 or 1.07, it is proved that air flowing through the space between the second wall **64** and the photosensitive drum **27** is directed to the direction from the exposure window **51***a* to the charger **29** and that air flowing through the openings **64***b* of the second wall **64** is directed to the direction from the inside to the outside of the process cartridge **17**. However, when compared with the results between the conditions of A/B is 0.93 and A/B is 1.07, it is proved that the flow rate of air is smaller when A/B is 0.93. Accordingly, it is proved that the smaller is the ratio A/B, the more can be restricted for the flow of air interrupting the electric charge by the charge **29**. Therefore, when the condition A<B is satisfied, it is proved that ion flow generated upon electric charge by the charger **29** is not likely to be interrupted by other airflow.

What is claimed is:

1. An image forming apparatus comprising:

a photosensitive element;

a charger for electrically charging the photosensitive element;

an exposure device for scanning laser light across the photosensitive element that has been electrically charged by the charger;

an exposure window positioned away from the exposure device for a predetermined distance and through which the laser light passes; and

an exhaust fan for drawing air between the exposure device and the exposure window toward the charger and discharging the air from the image forming apparatus,

wherein the exposure window is defined by a plurality of walls, in which a first wall that is the farthest wall from the charger and a second wall that is the nearest wall from the charger satisfy a formula: A<B,

where A is a distance between the first wall and the exposure device, and B is a distance between the second wall and the exposure device.

2. An image forming apparatus according to claim **1**, wherein the exposure device is arranged in a position not across an extension extending from a line connecting a center of the photosensitive element and a center of the charger.

3. An image forming apparatus according to claim **1**, wherein the charger is of a corona discharge-type.

4. An image forming apparatus according to claim **1**, wherein the photosensitive element, the charger, and the exhaust fan are arranged in line.

5. An image forming apparatus according to claim **1**, wherein a flow direction of airflow coming from the exposure window is bent around the charger in a direction away from the photosensitive element.

6. An image forming apparatus according to claim **1**, wherein an airway for flowing the air is formed in a longitudinal direction of the image forming apparatus between the exposure device and a drum unit which supports the photosensitive element and the charger, and wherein a flow rectifying duct is provided at a position opposed to an outlet of the airway such that a flow direction of airflow coming from the exposure window is bent around the charger in a direction away from the photosensitive element.

7. An image forming apparatus according to claim **1**, wherein the distance A and the distance B satisfy a formula: A/B<0.8.

8. An image forming apparatus according to claim **1**, wherein a distance from the first wall to the second wall is in a range from 5 to 30 mm.

9. An image forming apparatus according to claim **1**, wherein a projection is formed at least one of on the first wall and on a wall surface of the exposure device which is opposed to the first wall so that an airflow passage is restricted.

* * * * *